PRECIstep

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Step Motor DRIVER
Constant Current Mode

USER MANUAL
AD CM M1S
AD CM M2S
AD CM M3S

Revision 4

FAULHABER GROUP
We create motion

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Miniature Stepper Motors
Precision Gearheads
Encoders
Drive Electronics

User Manual
PRECISTEP Step Motor DRIVER AD CM M_S

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1. General Information

1.1. Product Description

The main interest of the use of a current mode driver such as the AD CM models is the current control independent from the supply voltage. This allows to apply a much higher voltage than needed to drive the current without risk of overheat.
A higher supply voltage allows the motor develop more back-EMF the motor may develop can be higher. Therefore the results in a more constant torque output of the motor up to higher speeds and the possibility to boost motor currents if suitable.

The drivers AM CM M_S are specifically designed to control the phase current in current mode operation of PRECISTEP two phases stepper motors.
They offer

- Full - half-step operation
- Current control (preset currents – 16 levels)
- STANDBY – current decay to 33% of set operation current level
- BOOST – current increase to 150% of set operation current level
- DISABLE- current is Zero (windings open/shorted)
- One-phase ON, two-phase ON operation (switch selected)
- INHIBIT – not phase current to save energy

Product Note

DO NOT

Connect Motor Phase Outputs A+, A-, B+, B-
to Power Positive Supply Voltage
This will cause fatal damage to the driver

1.1.1. Available versions

The AD CM M_S is available in three different versions

.1 **AD CM M1S (**Standard stock item)
Basic drive, composed of a translator (full-step, half-step) and the power drivers, it requires only clock and direction signals and is destined to be controlled by a PC or other host.
It is able to control the position of the rotor shaft.

Please refer also to the Product Block Diagram Chapter 2.1

.2 **AD CM M2S (**Non-Standard – available on request only)
Basic drive AD CM M1S including a plug-in board with a pulse generator to run a step motors at a fixed speed. The speed is set manually with a potentiometer.
This version is good for speed control in start-stop mode (pull-in) operation.
Unplugging the blue jumpers will transform the unit into the AD CM M1S.

Please refer also to the Product Block Diagram Chapter 3.1

.3 **AD CM M3S (**Standard stock item)
Basic drive AD CM M1S including a plug-in board with a pulse generator to run a step motors with a trapezoidal speed profile starting/stopping at a start stop frequency. The start stop frequency, maximum frequency, ramp time can be set manually with potentiometers.
This is a standalone step motor controller mainly used for step motor bench tests.
Unplugging the blue jumpers will transform the unit into the AD CM M1S.

Please refer also to the Product Block Diagram Chapter 4.1

1.2. Technical Specifications

Current Mode Driver, the current level is preset by on-board switches.
The stepper motor drivers AD CM M_ designed to drive the small stepper motors type AM in full step, wave and half step mode.

			AD CM M1S	AD CM M2	AD CM M3S
Power supply voltage	Min Max	V	10 28		
Power supply current		mA	12		
Motor Output current	max.	mA	750		
Output current setting	1 2 3	mA	Can be set in 16 step of 50mA from 50 to 750mA		
Logic input level	low high	V	0 to 0.6 1.6 to 24		
Direction of rotation			cw/ccw		
Step mode			full step (two phase ON full-step (one phase ON (wave) half step		
Step frequency	Min max.	full step/s	--- ---	0 6000	0 6000
Dimensions		mm	83.2x53.5x12	83.2x53.5x22	83.2x53.5x22

Conventional Information
1. Logic Low 0 - 0.6V
2. Logic High 1.6 - 24V

1.3. Protection of In- and Outputs

The AD CM M_S versions are offering increased protection levels for the in and outputs.

The listing shows the protection rating of the different in- and outputs
for both the actual AD CM M_S and the previous version.

If one of the non protected events occurs the driver will be damaged.

Driver output short-circuit			AD CM M_S	AD CM M_
Driver OUT	versus	GND	☺ protected	☹ not protected
Driver OUT	versus	V+	☹ not protected	☹ not protected
Driver OUT	versus	Pin 1-2	☺ protected	☹ not protected
Driver OUT	versus	Pin 1-3	☺ protected	☹ not protected
Driver OUT	versus	Pin 1-4	☺ protected	☹ not protected
Driver OUT	versus	Pin 2-3	☺ protected	☹ not protected
Driver OUT	versus	Pin 2-4	☺ protected	☹ not protected
Driver OUT	versus	Pin 3-4	☺ protected	☹ not protected

Protection on COMMAND				
Inputs	versus	V+	☺ protected	☺ protected
Inputs	versus	GND	☺ protected	☺ protected
Outputs	versus	V+	☹ not protected	☹ not protected
Outputs	versus	GND	☺ protected	☺ protected
Pin +5V	versus	GND	☹ not protected	☹ not protected

1.4. Suitable PRECISTEP Motors

The driver of the series AD CM M_S is specifically suitable for motors with windings designed for constant current control:

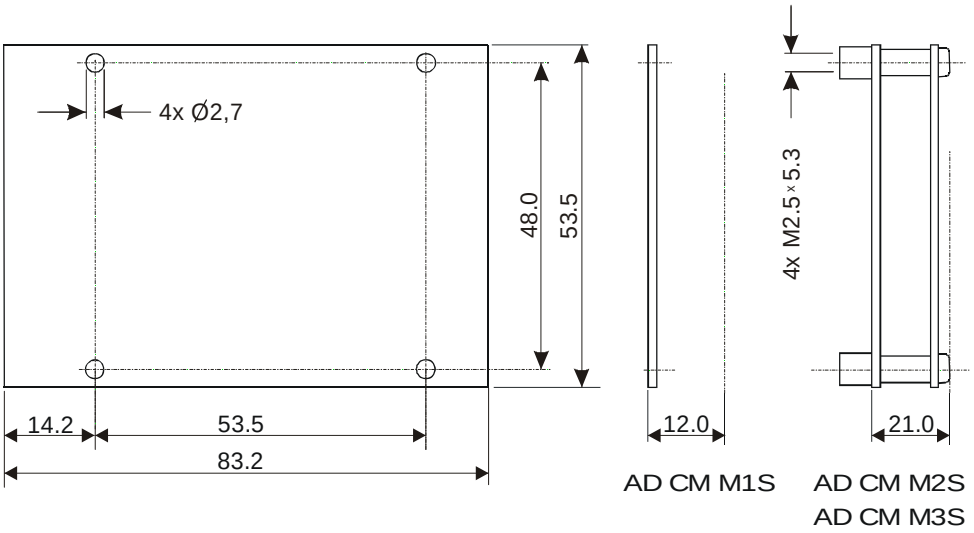
Motor Type	Current setting	Notes
ADM0620		
AM0820-A-0.225-7	4 or 5	Nominal current for continuous operation is 0.225Am please check heating of the motor in your application
AM1020-A-0,25-8	5	
ADM1220		
AM1524-A-0.25-12.5	5	
AM1524-A-0.45-3.6???	9	Lower voltage operation motor
AM2224-AV-4.8	10	

Voltage control motors of the types AM0820-V-3; V-5 or AM1020-V-3; V-6; V-12 or AM1524-V-V-3; V-6; V-12 may be driven also in current control mode. However, the nominal current of the datasheet is not suitable to drive the motor continuously with this current, please use lower setting.
Some voltage mode motors may offer a reduced operational speed because of their high back-EMF.

NOTE:
The higher the voltage of the supply is, the more torque the motor will develop at high speed.

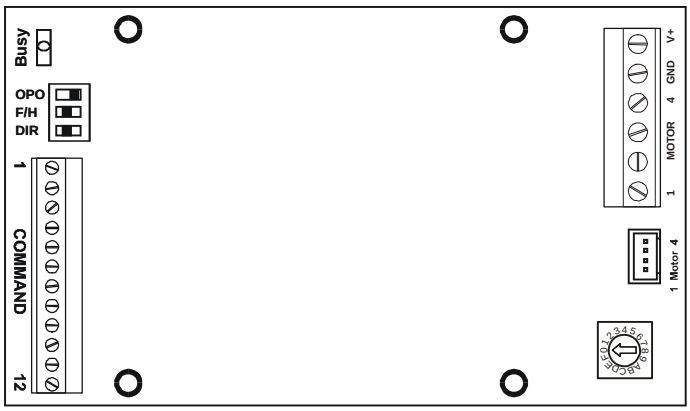
1.5. Dimensions and mounting

The drivers are prepared to be mounted using the shown prepared holes on the M1. The M2 and M3 consist of two boards; their assembly is possible by the tapped holes at the bottom of the assembly.



Dimensions and mounting

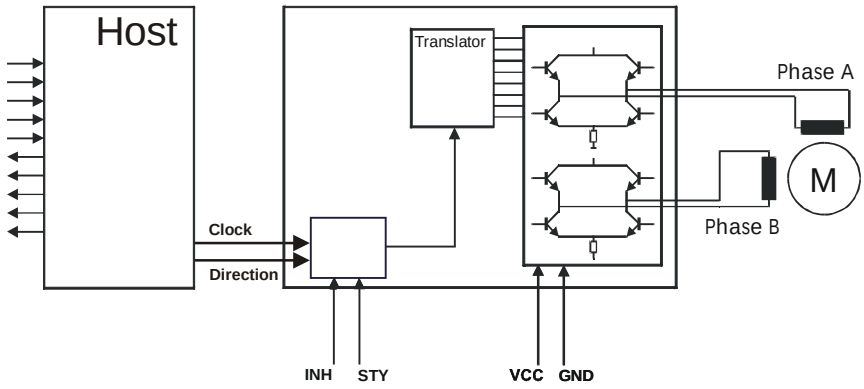
The following provides the position of the pin 1 of Motor (4 cavities) and Command (12 cavities) connectors relative to the mounting holes.



2. Set-up and installation AD CM M1S

This section refers in principal to all functions offered of the step motor drivers type AD CM M1S, the set-up of the M2S and M3S version is, relative to the functions of the M1S the same but offer some additional functionalities.

2.1. Block Diagram



2.2. Location of Components

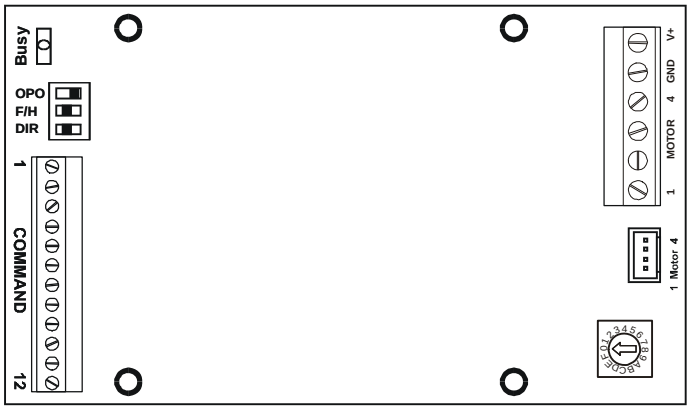


Fig.: Component location AD CM M1S

2.3. Connection of the drives

This section will introduce to the functions of the Version AD CM M1S, which is the identical board for all versions of the AD CM M_S.
Please refer to sections 2.2 for the installation and set-up of the additional functions offered by the versions AD CM M2S and AD CM M3S. Note. Both of these versions can be used as AD CM M1S, the moment the jumpers ADJ, VCO, CK are or the mezzanine board are removed.

2.4. COMMAND" connector

Input voltage for all inputs variable from 5-24VDC
This connector is available on all driver versions, it provides access to all functionality of the respective using through a 12pin header for a processor, PC or PLC.

#	I/O Type	Sign	Explanation	M1	M2	M3
1	I	1-PH ON	Full-step; 1-phase ON (wave)	X	X	X
2	I	FS/HS	Full Step-Half Step mode switch	X	X	X
3	I	CCW/CW	Sense of rotation switch, default = CW	X	X	X
4	I	CLK	External clock input	X	X	X
5	I	RUN	Starts the clock generator **		X	X
6	I	STOP	"STOP" : stops the clock generator		X	X
7	I	STB	Current Standby	X	X	X
8	O	BUSY	Output = Low when clock is active		X	X
9	I	BOOST	Current boost	X	X	X
10	N	VCC	+5V power supply,	X	X	X
11	N	GND	Ground potential ⇒ 0 Volt	X	X	X
12	I	VCO	External control voltage for the oscillator (VCO)		X	X
	O	HOME	Active when Phase A is commutated with positive current	X		

CLK input is active on positive trigger signal

O = Output, for more information please refer to ….
I = Input, for more information please refer to …
N = Neutral, sink and source pins, to connect directly

Functional description of the Inputs/Outputs on COMMAND connector:

PIN1, Operation Mode Selection
Selected can be ONE-Phase ON commutation (LH) or twp phase ON (LL)
Input is not active if not connected
With 1-phase-ON, the motor provides the same torque than with 2-phase-ON mode, but with a lower current consumption. The AD CM M1S increases the current in the activated motor phase by a factor of 1.41.

PIN2 Step resolution selection
Input is not active if not connected.
Selected can be Full-step (LL) or Half-step (LH)

PIN 1+2 Truth-table

PIN 1	PIN 2	Function mode
LL	LL	Full-step, two phases ON
LH	LL	Full-step, one-phase ON
LL	LH	Half-step
LH	LH	Full-step, one-phase ON

The motor torque will be the two phase ON torque at all rotor positions (corrected torque ripple). The driver corrects the current by a factor of 1.41 for all positions of the commutation sequence where one phase is activates.

PIN3 Direction of rotation
The signal can be changed at any time, it takes effect after the next following clock signal, it is even possible to trigger a clock and direction at the same time, the step execution is already in the opposite direction.

PIN4 External clock signal.
This input enables the host to control the position of the rotor exactly to an exact number of steps. Each positive trigger impulse moves the motor by one step (full-step or half-step dependent on setting of PIN1 or 2).
Is has no function when ON-board CLK (versions M2, M3) is active.

PIN5 RUN Command Input - Only available on M2 and M3 version,
Activated by a positive edge of the signal

PIN6 STOP Command Input - Only available on M2 and M3 version,
Activated by a positive edge of the signal

PIN7 Standby signal
Current to the motor phases is reduced to 33% of the operation current level as long as this input is active
For more information see PIN7+9 Truth Table below (under Pin 7+9).

PIN8 BUSY Output –
(Available on M2 and M3 version, and on M1 pulsed with CLK lower than 25Hz, always active when CLK Frequency is higher
Open collector output, not short circuit protected.

PIN 9 Current boost operation
The current increases by factor of 1.5 as long as this input is active
For more information see PIN7+9 Truth Table below (under Pin 7+9).

PIN7+9 Truth table

Pin 7 Standby	Pin 9 Boost	Function
LL	LL	Enable
LL	LH	Boost
LH	LL	Standby
LH	LH	Disable

Conventional Information
3. Logic Low (LL) 0 - 0.6V
4. Logic High(LH) 1.6 - 24V

PIN10 +5V power supply output
Maximum current 200mA, source output

PIN11 GND general (for the VCO voltage source - Only available on M2 and M3 version)

PIN12 Input VCO or Output HOME
The selection is done by a solder bridge behind the command header.

Functions

HOME is a function needed to know the commutation position of the driver.
It is activated every time Phase A of the motor is energized with positive current.
This helps to home the clock of the host to the driver commutation a function helpful to avoid step losses when power to the driver is lost. If the motor is stopped with this output triggered the motor will not move uncontrolled upon power-up.

VCO
Input only available on M2 and M3 version
Range = 0 to 5V corresponding to Zero up to 6000Hz max.

Switching from full to half step operation or vice versa will not change the motor shaft speed.

2.4.1. Operation Mode Selector Switch

To operate the driver, it is also possible to work without using the COMMAND connector, In this case the selection of the Drive Mode

The hardware switches replace the need to use the Command Inputs.
Their operation is as follows:

Switch	Switch Function
OPO	1-PH ON selector
F/H	Full-step, Half-step selector
DIR	Sense of rotation

Truth table for the OPO and F/H Switches

Status OPO	Status F/H	Function mode
OFF	OFF	Full-step, two-phase ON
ON	OFF(/ON)	Full-step, one-phase ON
OFF/ON	ON	Half-step,(two-phase ON*)

* current correction activated, torque remains the same in all rotor positions.

2.4.2. LED (near COMMAND connector)

LED active only on when motor is moving
(not operational on AD CM M1S boards) see above

2.4.3. MOTOR Connector/Power Supply

The driver comes with a screw type terminal for the connection of the power supply

	Pin #	Function
	1	V+
	2	GND
	3	Phase B -
	4	Phase B +
	5	Phase A -
	6	Phase A +

	Pin #	Motor Phase	Motor PIN
	1	Phase A +	1
	2	Phase A -	2
	3	Phase B +	3
	4	Phase B -	4

Connector Type: Molex
Mating Connector: Housing - Molex 51021-0400
Pins Moles 50058-8000

A cable with this mating connector is not supplied with the driver
It is optional and can be ordered with Part Number 2.8000.15.077.
It is supplied separately from motor and driver.

2.4.4. Current setting, rotary switch

	Rotary Position	Current level
	0	0
	1	50
	2	100
	3	150
	4	200
	5	250
	6	300
	7	350
	8	400
	9	450
	A	500
	B	550
	C	600
	D	650
	E	700
	F	750

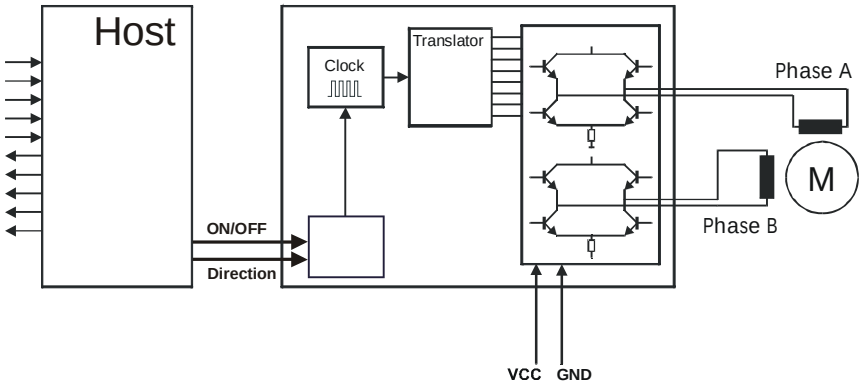
3. Set-up of the AD CM M2S

For hook-up and functions of the AD CM M2S it is required to look-up also the functions of the AD CM M1S. The AD CM M2S includes a mezzanine (plug-in) board which offers:

- on-board clock
- Single speed setting trough potentiometer

Note: The driver AD CM M2S does not offer a speed ramp, it is able to operate he motor only at a single speed which has to be reached during the first step, generally at less than 200-600 Hz (depending on load)

3.1. Block Diagram



3.2. Location of Components

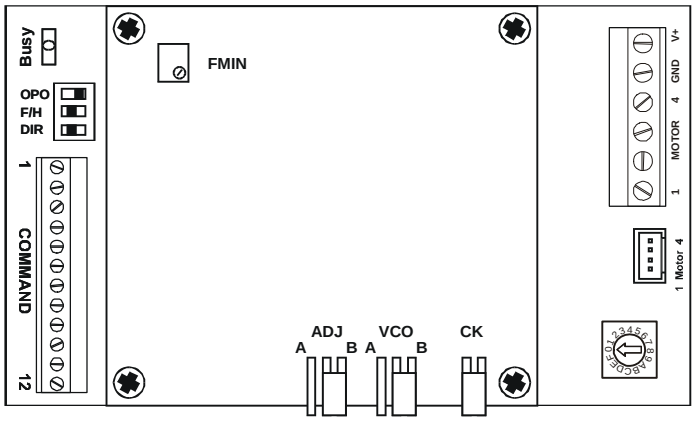


Fig.: Component location AD CM M2S

3.3. Adjustment of the speed

To set-up the motor speed

- Turn FMIN potentiometer CCW to zero
- Set Jumper ADJ to position A
- Set Jumper VCO to position A
- See whether the motor starts and adjust FMIN potentiometer until the motor starts with the application load. This determines the maximally possible pull-in frequency. It his however possible to set the speed to any lower value.

Note the motor will reach the MIN speed within the first step (pull-in speed range), no ramp is used. If the motor does not execute please consider to use the AD CM M3S.

3.4. Operation of the AD CM M2

- Jumpers VCO and ADJ in Position A, motor starts upon power up
  The inputs RUN, STOP have no function
- Jumper VCO in Position A, Jumper ADJ in Position B, motor will react on the inputs RUN, STOP

3.4.1. Jumper ADJ = Adjust

Position A
The motor rotates on the set MIN operation speed settings.

Button/input RUN:	motor will operate at FMIN speed
Button/Input STOP:	motor will stop

Position B
No function, do not use this setting, undefined speed may occur.

3.4.2. Jumper VCO = Voltage Controlled Oscillator

Position A
The on-board frequency generator is activate, motor speed is set by the on-board FMIN potentiometer.

Position B
The external Analogue Speed Reference input is used
(PIN 12 on COMMAND connector),

3.4.3. Switches/buttons RUN and STOP

(buttons not present on all boards)

Condition for correct function Jmp. ADJ in Pos. B, Jmp. VCO in Pos. A,

NOTE:
PIN 5 and 6 on the COMMAND connector has the same identical function, in case that the PIN 5 is activated (5 to 24VDC applied), the RUN button has no function.

RUN Function:	Starts the motor to operate,
STOP Function	Stops the motor to operate, the motor stops immediately

3.4.4. Jumper CK = Clock

Jumper SET,	the internal clock generator is active If an external clock is used at the same time (clock signal present on PIN 4 on COMMAND connector), the speed is no longer controlled by any of the clock signals.
Jumper NOT SET:	Only the external Clock Signal (clock signal present on PIN 4 on COMMAND connector) will be taken into account, ramp generator is OFF as well.

4. Set-up of the AD CM M3S

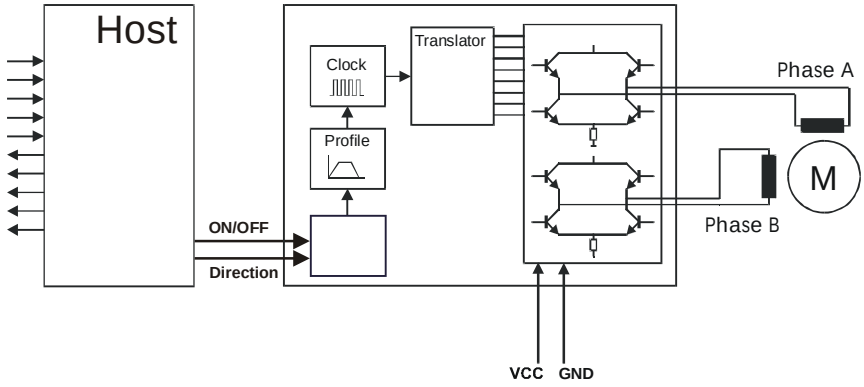
For hook-up and functions of the AD CM M3S it is required to look-up also the functions of the AD CM M1S. The AD CM M3S includes a mezzanine (plug-in) board which offers:

- on-board clock
- MIN and Max Speed settings
- ACC and DEC (acceleration and deceleration time setting)

The functions are partially shared with the M1 board, to determine the function of the plug-in board with the M1 base board, a series of jumpers is available.

For the use of these functions please refer to the following section

4.1. Block Diagram



4.2. Location of Components

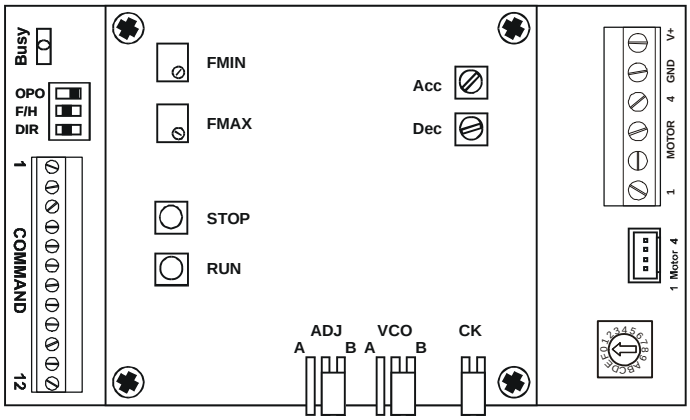
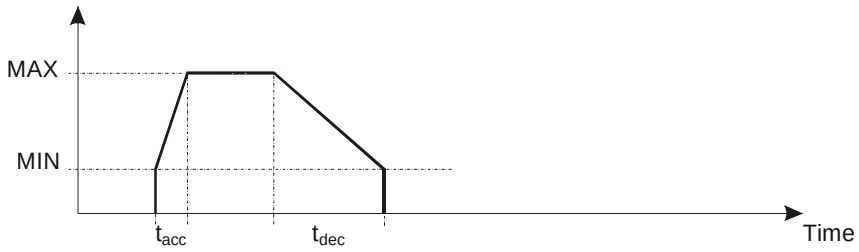


Fig.: Component location AD CM M3S

4.3. Adjustment of the Speed Profile

The Potentiometers MIN, MAX, ACC, DEC located on the Plug-in Board are used to set the parameters of the Speed profile used to move the motor.
The function and adjustment methods are explained below.

4.3.1. Speed Profile Graphic Description



4.3.2. MIN potentiometer

Function:
The potentiometer serves to set the minimum speed of the motor.
To set-up the minimum speed

- Turn MAX potentiometer CCW to zero
- Set Jumper ADJ to position B
- Press Start to see whether the motor starts
  and adjust MIN potentiometer until the motor starts with the application load.

Note, the motor will reach the MIN speed within the first step (pull-in speed range), no ramp is used

4.3.3. MAX potentiometer

Function:
The potentiometer is used to determine the maximum speed the motor will reach. To reach this speed the motor will require and acceleration and a deceleration ramp respectively.

The set-up is done as follows:

- SET_UP MIN speed
- Increase the ACC and DEC ramp by adjusting the corresponding potentiometers on the board (see ACC and DEC Adjustment)
- Increase the MAX speed by turning CW
- If the motor does not accelerate to the speed (stalling of motor shaft) increase the ACC time (acceleration time given to the motor to reach the MAX speed) by turning the ACC potentiometer CCW

NOTE: Maximum speed changes as well when MIN setting is changed, the difference is not changing

4.3.4. ACC and DEC Adjustment

Function:
The potentiometers adjust the time at which the motor will accelerate from MIN to MAX speed.

- Turning the potentiometer CW will increase the acceleration (t_{acc} and t_{acc} ↘), the motor speed increases/decreases faster
- Turning the potentiometer CCW will decrease the acceleration ((t_{acc} and t_{acc} ↗), the motor speed increases/decreases slower

4.4. Operation of the AD CM M3S

- The Buttons RUN, STOP allow, to operate the motors manually.
  See details below.
  The functions RUN, STOP are available also on the COMMAND connector and are operating in parallel to the switches.
- The Jumpers ADJ, VCO, CK determine specific operation parameters.
  Please refer to the corresponding section below.

4.4.1. Switches/buttons RUN and STOP

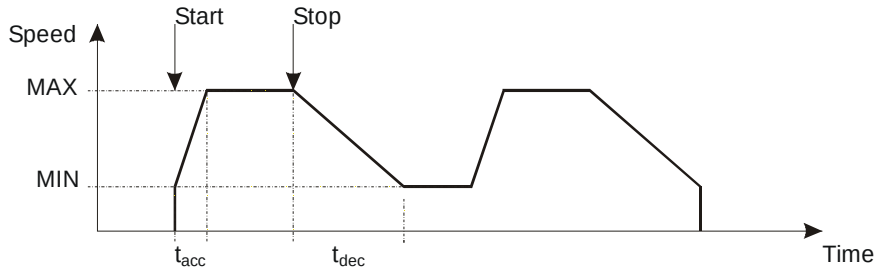
RUN Function:
Starts the motor to operate,
NOTE: the PIN 5 on the COMMAND connector has the same identical function, in case that the PIN 5 is activated (5 to 24VDC applied), the RUN button has no function

STOP Function
Stops the motor to operate, the actual function is that the motor starts to decelerate the moment Stop is activated or pressed,
NOTE: the PIN 5 on the COMMAND connector has the same identical function, in case that the PIN 5 is activated (5 to 24VDC applied), the RUN button has no function

4.4.2. Jumper ADJ = Adjust

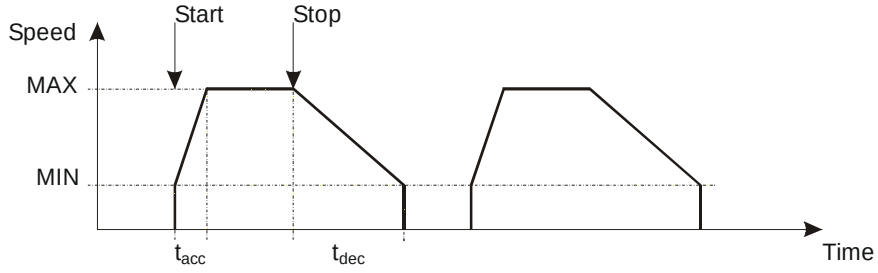
Position A
The motor rotates on the set MIN and Max operation speed settings.

Button RUN pressed:	Acceleration from MIN speed to MAX speed
Button STOP pressed:	Motor will decelerate but will continue to run at the speed setting of the MIN.



Position B
The motor rotates on the set MIN and Max operation speed settings but will stop automatically after the deceleration (when the MIN speed has been reached)

Button RUN pressed:	Acceleration from MIN speed to MAX speed
Button STOP pressed:	Motor will decelerate and stop rotating



4.4.3. Jumper VCO = Voltage Controlled Oscillator

Position A
The on-board ramp generator is activated and used to influence the acceleration time of the motor from Min to Max clock speed.

Position B
The external Analogue Speed Reference input is used
(PIN 12 on COMMAND connector)

4.4.4. Jumper CK = Clock

Function:

Jumper SET,	the internal clock generator is active. If an external clock is used at the same time (clock signal present on PIN 4 on COMMAND connector), the speed is no longer controlled by any of the clock signals.
Jumper NOT SET:	Only the external Clock Signal (clock signal present on PIN 4 on COMMAND connector) will be taken into account, ramp generator is OFF as well.

5. Special NOTES

5.1. Pull-up resistor

Pull Up
The inputs of the drivers namely clock, direction, START; STOP are open collector inputs.
Open Collector (or Open Drain) output is frequently offered by programmable logics because of their higher safety.
They require an adaptation to the AD driver series with a PULL-UP resistor.

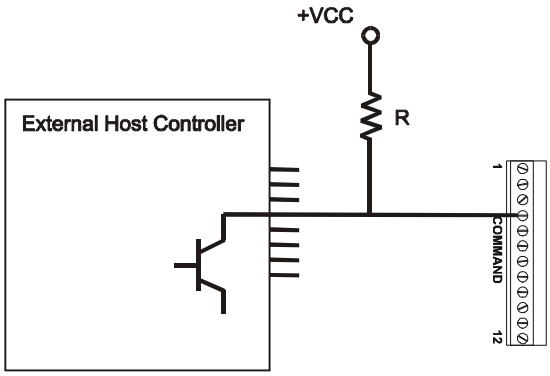


Fig.: pull-up resistor connexion

This configuration is necessary for the inputs/ouputs 1-7 of all PreciStep drivers.

The value of resistor used to pull up an open-collector is not critical. Smaller values offer faster switching times at the price of higher current consumption.
Typical values range from a few thousand to a few hundred thousand Ohms.

Please note that the signal is inversed this way.

Versions:

V4900UM240904_CD	first tracked version	24.09.2004.06.04
V4900UM240205_DC	Release with new product	24.02.2005
V4900UM051005_CD	Updated PIN-out info and safety notice	05.10.2005
V4900UM241105_CD-R1	Correction of optional cable part number	24.11.2005
V4900UM161205_CD-R2	Correction of suitable motors	16.12.2005
V4900UM210706_CD-R3	Protection rating added, M2.5 screw correction	21.07.2006
V4900UM080408_CD-R4	Name Update Precistep	08.04.2008

Product denominator key

Typical Product type **AD CM M1S**

AD **D**river product category

C V = Constant **C**urrent drive

M Mode

M1 Function Mode
M1 = Pulse + direction drive, external control
M2 = Speed control drive w/o speed ramp (non-standard)
M3 = Speed control drive with speed ramp

S External connection type
S = screw type for all connectors
SP = Screw type for supply and motor, pins for COMMAND (Special pin out)